Public Health in Practice 5 (2023) 100396

Contents lists available at ScienceDirect

Public Health in Practice

journal homepage: www.sciencedirect.com/journal/public-health-in-practice

Health gains from home energy efficiency measures: The missing evidence in the UK net-zero policy debate

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ARTICLE INFO

Keywords:
Energy efficiency
Net zero
Housing
Hospitalisations
Respiratory
Cardiovascular

ABSTRACT

Objectives: This study examined the health gains from a programme of external wall insulation works to homes in south-west Scotland, and in particular the impact upon hospitalisations for respiratory and cardiovascular conditions. Furthermore, to consider how evidence on health outcomes could form part of the debate around actions to meet net-zero goals in the UK.
Study design: This was a two-part study. Part one involved before-and-after interviews with 229 recipient households. The second part comprised an observational study of hospital admissions in 184 postcode areas.
Methods: Across three years, interviews collected thermal comfort and self-reported health data(Sf-36) in the winter months prior to installation, and again in follow-up interviews the next winter. Standarised monthly data on non-elective admissions for each set of conditions were compared between the intervention postcodes and the wider health board area over a ten year period.
Results: Following receipt of wall insulation, inability to achieve thermal comfort in winter reduced by two-thirds. Improvements in thermal comfort were associated with gains in physical health scores. Relative standardised admissions fell in the treatment areas, remaining lower than the district-wide standardised rate for the majority of a five year period, this effect ending during the Covid-19 pandemic. The impact on admissions was greater for respiratory conditions than for cardiovascular conditions.
Conclusion: A weak policy commitment to energy efficiency could be strengthened with further evidence of the cost-savings and reduced hospital bed demand resulting from insulations works. The potential health gain may also encourage more home owners to participate.

What this study adds

- Evidence from one of the few UK studies of the impacts of home energy efficiency measures upon hospital admissions.
- External wall insulation resulted in improved thermal comfort which in turn was associated with improved self-reported physical health.
- Treatment areas exhibited relatively lower hospital admissions for up to five years, with the effect being greater for respiratory than for cardiovascular conditions.

Implications for policy and practice

- Home energy efficiency measures should be considered as a preventative health intervention, targeted at vulnerable individuals as well as being delivered on an area-wide basis.
- Setting a higher home energy efficiency standard to be achieved through housing improvements might deliver greater health gains.
- Viewing home energy efficiency measures as having multiple benefits, including reducing the demand for health services, should inform government priorities for achieving Net Zero.

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https://doi.org/10.1016/j.puhip.2023.100396
Received 24 October 2022; Received in revised form 19 May 2023; Accepted 22 May 2023
Available online 25 May 2023

1. Introduction

The UK has a backlog of home energy efficiency works. In 2019, it was reported that around 70% of the UK housing stock had an energy efficiency rating of D or below (rating from A – G), while only 1% achieved the top ratings A-B. Energy efficiency works to homes have plumetted: wall insulation works peaked at 600,000 per annum in 2012 but fell to below 100,000 by 2017 [1]. The relevant House of Commons Committee noted that ' … UK Government policy will fail to upgrade the remaining 70%' of properties not yet at Band C (p.13) [1].

Improving homes through insulation and improved heating has been seen as a counter to fuel poverty [2]. Since at least 2011 under the UK Fuel Poverty Strategy, all four UK nations have had home energy efficiency programmes with similar titles, e.g. Warm Front (England), Warm Deal and Central Heating Programme (Scotland), Home Energy Efficiency Scheme (Wales), and Warm Homes (Northern Ireland). These and subsequent programmes were often assessed in terms of their energy savings, reductions in fuel bills and fuel poverty, or economic impacts, for example their impact on gas demand [3]. Warmer Homes Scotland, described as 'the Scottish Government's flagship national fuel poverty scheme', comprises a mixture of heating and insulation measures and provides annual savings to households averaging £319 per annum [4].

Energy efficiency programmes are now also commended for carbon reduction and net-zero reasons. Of five areas for urgent housing action identified by the UK Committee on Climate Change (CCC), one was to strengthen policies to retrofit existing homes and make them more thermally efficient [5]. Indeed, the CCC argued that without a large-scale energy efficiency programme for the UK's building stock (homes and factories etc.), there would be no credible strategy to meet the net zero target by 2050 (2045 for buildings in Scotland), as enshrined in The Climate Change Act 2008 and amended in 2019 [6]. On climate change grounds alone, energy efficiency works can be considered a public health intervention.

The government has intertwined its carbon-reduction and fuel-poverty objectives through a series of recent energy efficiency targets. In its Fuel Poverty Strategy for England the government aimed to improve the energy efficiency of the homes of those in fuel poverty 'as far as reasonably practicable' to EPC Band C by 2030 [7], with just 10% of fuel poor households residing in such properties at the time [1]. Two years later, the Government went further in its Clean Growth Strategy, setting a target that all rented homes should be at EPC Band C by 2030, and all other homes by 2035, where 'cost effective, affordable and practical' [8]. The place of health in such policies is revealed by the fact that the scrutiny committee of the House of Commons listed 'NHS savings' as 7th out of 8 'wider benefits' from the programme, several places below jobs and economic growth [1].

There has been a systematic lack of investment and policy targets for home improvement schemes. Not long after the Clean Growth Strategy was published, the Department for Business Energy and Industrial Strategy (BEIS) admitted that it had not made an estimate of the level of investment required to meet its 2035 home energy efficiency target [9]. The UK Government's weak approach is exemplified by its Green Homes Grant (GHG) Voucher Scheme. GHG was announced in July 2020, aiming to spend £1.5bn to improve 600,000 homes. However, it was closed in March 2021, having spent £300 m (20% of the anticipated spend) on 47,500 homes (8% of the number intended). An inquiry concluded that it was overly complicated, poorly designed, had unrealistic timescales, was badly administered and had poor customer experience [10]. The head of the UK's CCC has rated government policy on home insulation as 'very poor' for two reasons: the government is not funding enough works; and, it is not providing enough incentives for owners to invest in the energy efficiency of their homes [11].

In the light of the above, it is worth considering an alternative perspective that considers energy efficiency works as important for their public health benefits. If it could be shown that energy efficiency improvements to homes resulted in fewer hospital admissions, especially for respiratory and cardiovascular conditions linked to cold or damp homes [12], this might have several impacts: increased public spending on housing to receive a wider social return on investment; higher participation rates by home owners willing to meet their share of the costs; more attention to home improvements as an 'upstream' intervention [13] to free-up bed capacity within the NHS and reduce hospital waiting lists [14].

There is limited evidence for the effects of home energy efficiency improvements upon hospital admissions for occupants, and similarly for the relationship between energy efficiency and health. Two studies have been conducted in Wales, with the first focusing on over 60s living in council homes. Wall insulation was associated with a 27% reduction in emergency hospital admissions for cardiovascular conditions and a 24% reduction for respiratory conditions, but loft insulation had no significant effects [15]. A larger study of energy efficiency works (most commonly solid wall insulation) in Wales with a 3–4 year follow up, found no association with A&E admissions for cardiorespiratory or respiratory-related conditions [16]. An increase in admissions for cardiovascular conditions was found for the over-60s, contrary to the previous study.

The only study in England has been a cross-sectional, ecological study of the assocation between the number of houses in an area which had received energy efficiency measures and a three-year average rate of A&E admissions for asthma, chronic obstructive pulmonary disease (COPD), and cardiovascular disease (CVD). It found a 1% increase in loft insulation to be associated with a 0.2–0.4% increase in hospital admissions for all three conditions [17]. Beyond the UK, a study of Pacific ethnic households in deprived areas in New Zealand found a signficant reduction in all-cause (−23%) and housing-related (respiratory and infectious diseases) (−27%) hospital admissions following home improvement works (including insulation) for those aged 5–34, but an increase in housing-related admissions for those aged over 35 (+31%) [18].

These findings suggest that the health impacts of energy efficiency measures may be context-specific and differentiated by resident group. A meta-analysis of thirty-six global studies concluded that there was '*a small but significant improvement in the health of residents'* after energy efficiency measures [19]. However, the health outcomes were self-reported in thirty studies, and only eleven studies included insulation works (in six cases combined with other measures). The aim of this study is to advance the debate, particularly in the UK, about the priority that ought to be given to home energy efficiency works as part of net-zero policy by adding to the evidence on health gains.

2. Methods

2.1. Intervention

This study is of the 'Home Energy Efficiency Programmes for Scotland: Area Based Schemes' (HEEPS:ABS) delivered since 2013 to tackle fuel poverty [20] and now named Energy Efficient Scotland: Area Based Schemes. Nearly £50 m per annum is spent in the poorest local areas to provide over 10,000 measures, 80% being external wall insulation [4], the intervention being delivered in South West Scotland through partnerships between the Energy Agency and local authorities. The Energy Agency is an independent charity appointed by South Ayrshire, East Ayrshire, and Dumfries and Galloway Councils to manage their ABS programmes, as studied here. The three council areas in south-west Scotland have a combined population of c.382,000.

This study is based on the first seven rounds of the programme, from 2013 to 2020. A total of 7201 properties were treated with external wall insulation works across the three council areas during this time. The average Energy Efficiency Rating (EER) of treated properties improved by 12.2%, moving the average property from a Band D to a Band C, above the average rating for houses in Ayrshire of Band D.

2.2. Household interview survey

Householders recruited to the programme in the winter months (October to February) of the years 2015–2017 were invited to participate in a pre-installation interview and a post-installation interview the following winter. The interview covered questions on property condition, thermal comfort and health, including admistration of the SF-36 health-related quality of life scale, from which the physical health component score was calculated [21]. Excluding cases with potentially confounding factors such as other improvements having been done to the property after the insulation works, or changes in occupancy, or unrelated major changes in health status during the interval, a total of 229 interviews were available for analysis.

2.3. Secondary data on hospital admissions

A study of hospital admissions was conducted with the cooperation of NHS Ayrshire and Arran Health Board. Intervention areas were defined as postcode areas where 50% or more of the properties had been treated, giving a total of 184 intervention postcodes, of which three quarters (73%) were in the lowest two quintiles of the Scottish Index of Multiple Deprivation [22]. The Health Board area as a whole comprises 184,687 dwellings (10,975 postcodes) of which half (54%) are in the lowest two quintiles of the SIMD [23].

This group of intervention postcodes was compared with all other postcodes in the health board area. The two variables of interest were monthly non-elective (emergency) admissions for two sets of conditions: respiratory conditions, sub-group J of the ICD-10 diagnostic coding system; and cardiovascular and circulatory conditions, sub-group I. Note that Covid-19 admissions are not included in the respiratory data, but recorded as a separate category. The data were extracted from NHSA&A's Trakcare Patient Management System from May 2011–September 2021, thus covering approximately two years pre- and post-installation.

The analysis involved two steps. First, the values for each series were standardized using the standardization function in Excel, based on the mean and variance of each data set. Standardization returns a normalized value from a distribution around the mean. The formula for standardization (standard score) is:

$$Z=(X-\mu)/\sigma$$

Where Z is the standardized value, X is the sample value, μ is the population mean, and σ is the standard deviation of the population.

This process rescales the values of the number of admissions per month for both the intervention group and for all Ayrshire and Arran postcodes (excepting the intervention group), allowing direct comparison between the time series for each of the two diagnostic groups. By subtracting the value for all Ayrshire and Arran from the value for the intervention, it is possible to observe the value of admissions in the intervention group relative to the admissions of the remainder of Ayrshire and Arran as a whole. A value above zero indicates that there are more admissions in the intervention group relative to the remainder while a value below zero indicates fewer admissions relative to the remainder of Ayrshire and Arran. These values are then plotted as a timeline so that key periods can be identified and an Anova test used to compare the mean values between the time periods.

3. Results

3.1. Survey findings

Of the 229 households, three-quarters (77%) contained either one or two persons, and just over half (56%) contained someone of pensionable age, reflecting the fact that the intervention was delivered to households containing a disproportionate number of older people.

Fig. 1 shows that there was a fall of two-thirds in the proportion of respondents unable to achieve thermal comfort in winter, from 24% to 9%, with three-quarters of respondents (74%) being able to 'keep warm enough' all the time in the winter following the intervention.

Fig. 2 further shows that where the occupant experienced a noticeable improvement in thermal comfort, stating that their home was 'much warmer' after the intervention, they also reported a greater increase in physical health. This was accompanied by thirty-three anecdotal reports of physical health improvements such as in respiratory conditions, seasonal illness, reductions in pain, and improved mobility [24].

3.2. Hospital admissions

Fig. 3 shows the results for non-elective respiratory admissions, divided into four periods. In the first period, pre-dating the intervention and while the intervention commenced, the standardised admission rate is higher in the intervention postcodes than across the health board area. In the second period, about a year into the intervention, the admission rate starts to drop in the intervention areas and remains below the district-wide rate for about two years as the intervention rolls out. In the third period, of about two-and-a-half years, still during the intervention period, the relative admission rate fluctuates, though mainly stays below the district-wide rate. Lastly, towards the end of the intervention period and thereafter, from winter 2019 onwards, the relative rate of admissions rises, and during 2020 and 2021, the period of the Covid-19 pandemic, returns to being above the rate for the health board area.

The pattern is very similar for cardiovascular admissions (Fig. 4), though with the notable exception that the relative standardised admission rate is much closer to the district-wide rate both before and during the intervention. The lowest relative standardised rate is −0.2 for cardiovascular compared with −0.6 for respiratory conditions, i.e. the impact on admissions is not as great for cardiovasclar conditions.

Fig. 5 shows that in the case of respiratory admissions, the mean relative standardised rate is significantly lower for both the second and third time periods (the main intervention periods) compared with period one, but this is only true for period three for cardiovascular admissions.

4. Discussion

We examined two of the seven individual outcomes identified in theoretical models for energy efficiency interventions, namely cardio-respiratory illness and thermal comfort [25,26]. We found improvements in thermal comfort following external wall insulation, in turn associated with improved self-reported physical health. Furthermore, the main treatment areas exhibited relatively lower hospital admissions for both respiratory and cardiovascular and circulatory conditions, compared to the surrounding region for a period of up to five years. The latter finding is in accord with the only other UK study of wall insulation works [15]. The lesser impact upon cardiovascular admissions echoes the findings of the only other UK study that compared the two outcomes [16].

Our study raises a number of issues for future research and policy in this area. The effects of different contexts requires further exploration, in terms of dwelling types, climate conditions, population characteristics and local health status and policy. In the Ayrshire case, relative reductions in hospital admissions, particulary respiratory illness, waned in 2019-20. This is partly an indirect effect of the pandemic, resulting (as elsewhere) in reduced hospital admissions across the region during acute waves of the virus and for months thereafter [27], which changed the context for relative admission rates from the intervention areas. We also expect that impacts of energy efficiency may be differentiated by resident group; previous UK research suggests the effects may differ by age, particularly for the over-60s [16], to which we might add ethnicity as an area of inquiry in the Scottish context [28].

Our findings suggest that thermal comfort should be considered an

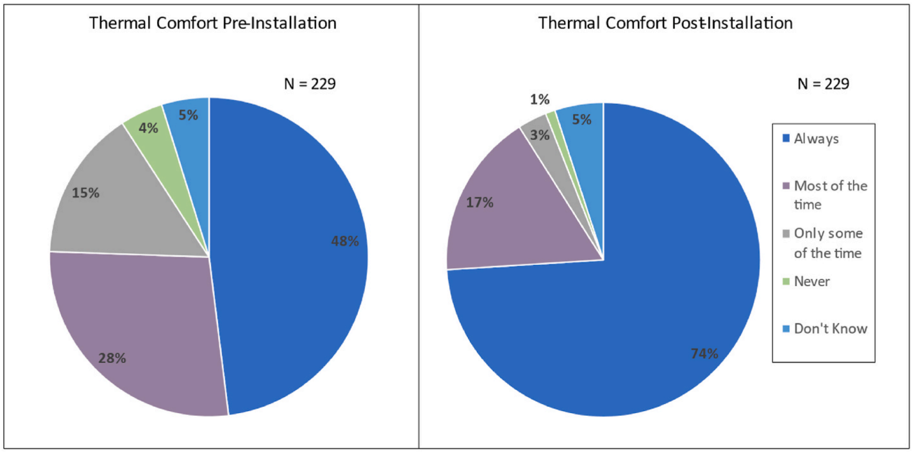

Fig. 1. Change in reported thermal comfort: "Does your heating keep you warm enough during winter?"

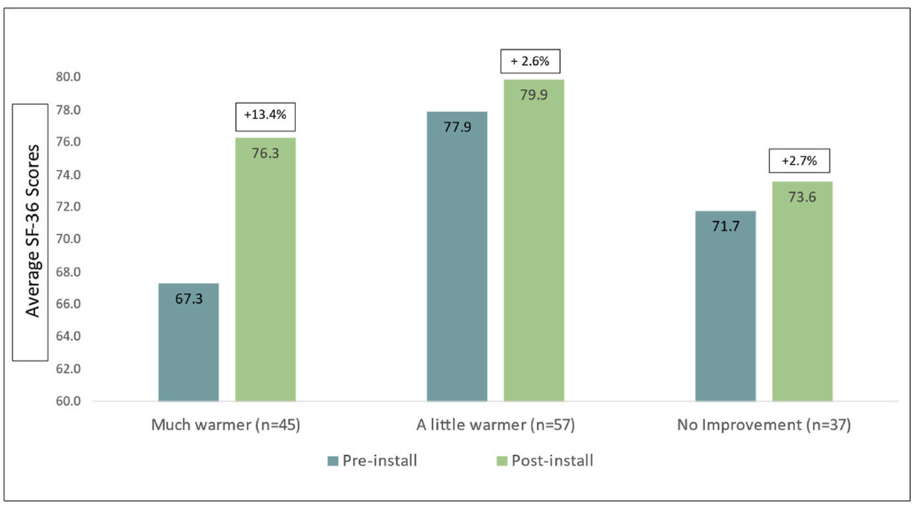

Fig. 2. Association between reported change in home warmth and physical health scores (SF-36).

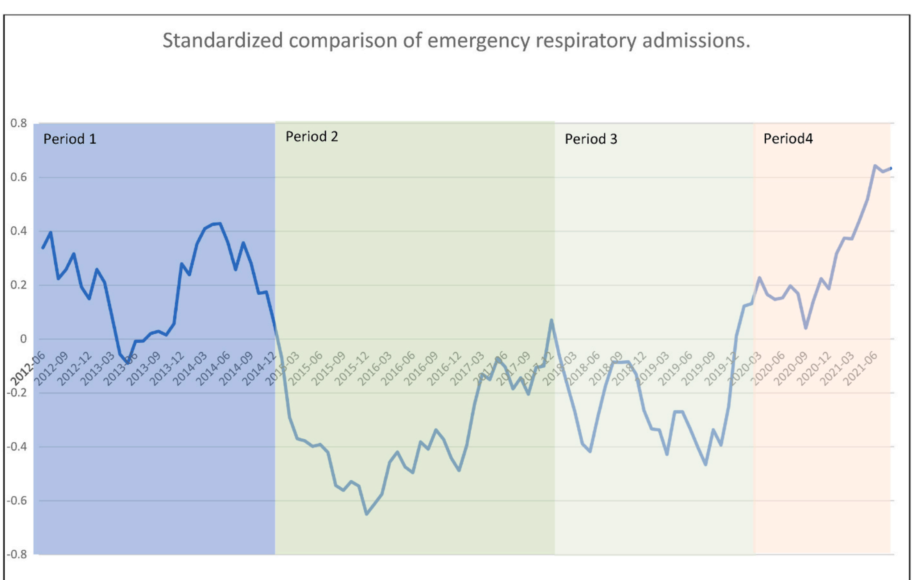

Fig. 3. Relative standardised emergency admission rate for respiratory conditions: intervention postcodes versus all other Ayrshire postcodes.

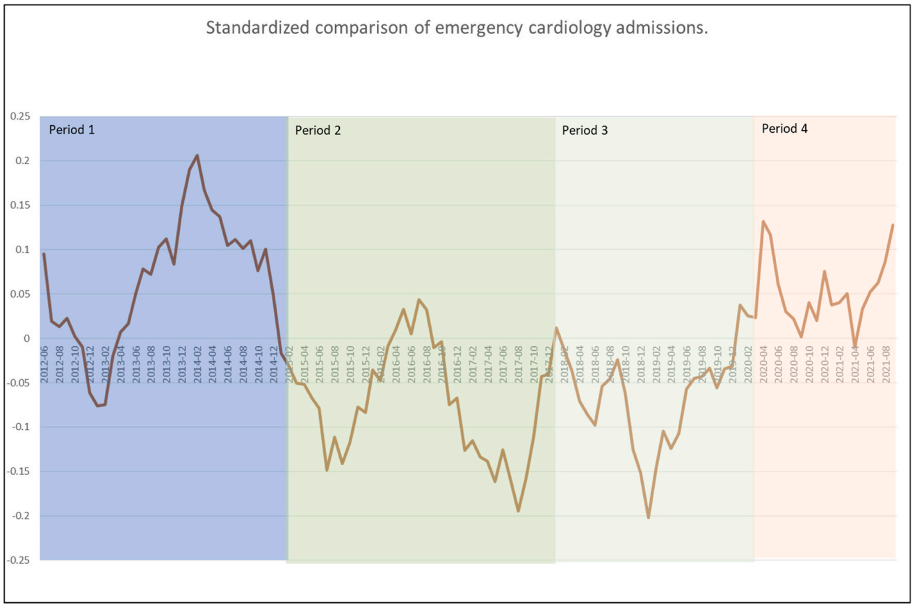

Fig. 4. Relative standardised emergency admission rate for cardiovascular and circulatory conditions: intervention postcodes versus all other Ayrshire postcodes.

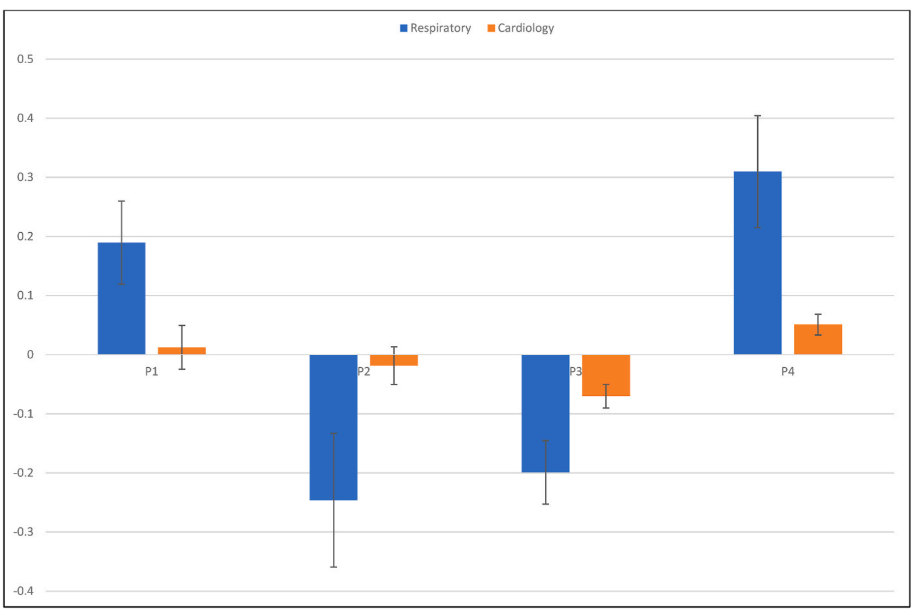

Fig. 5. Comparison of mean relative standardised values between four time periods, for respiratory and cardiology admissions. P < 0.000.

outcome from energy efficiency works, and/or a pathway to other health outcomes, in line with the understanding that thermal comfort protects health from the effects of high or low indoor temperatures [29], but nonetheless recognising that dynamic thermal conditions and temporary periods of thermal discomfort can also have health benefits [30]. Although not identified as a pathway to impacts in Scotland [26], the move towards an adaptive model of thermal comfort for homes without air conditioning, with an emphasis on occupant expectations and personal factors [31], suggests that more attention could be paid to its dual role in future. Duration of effect also requires more attention. We have shown effects over a maximum period of five years compared with many other studies examining shorter periods, and there are existing findings that housing improvement works have health impacts at different points in time and for different periods [32], but there is not much evidence overall. Future studies need regular follow-up periods over a decade or more to better establish the longevity of impacts from energy efficiency works.

In policy terms, our study raises questions of objectives and implementation. The intervention we studied raised properties on average to the upper bound of Band C on the EPC ratings, a policy target considered ‘challenging’ but ‘not a very high performance bar’ [33]. The question arises as to whether a higher policy target would deliver greater health gains, which is unkown since many studies have not reported the energy efficiency rating or change of treated properties. There is also a policy dilemma over efficiency in delivery versus effectiveness of impact. Most housing interventions, like this one, are organised on an area basis for efficiency of contractor delivery. However, we know impacts are greatest where interventions are targeted at those with the greatest potential health gain [34]. Housing policy has yet to satisfactorily combine these twin objectives, where health gains might be greater.

The biggest policy question, however, is whether evidence for reduced hospitalisations as a result of energy efficiency works to homes might increase government commitment to improving dwelling quality. Some years ago, it was estimated that the total cost of eradicating 'cold homes' in the UK was £6bn, with savings to the NHS of £848 m per annum - a pay-back period of 7 years [35]. These projected savings could be updated for insulation works alone to contribute to the debate over how and when to move to net zero. The All Party Parliamentary Group for Healthy Homes and Buildings has called for better measurement of the economic and social impacts of healthier homes [36]. The multiple benefits from energy efficiency works of reducing energy demand (and thus household bills), contributing to net zero goals, and alleviating pressures on health service bed-spaces is an exemplar of joined-up policy with political and practical attractions.

The UK Government's Net Zero Strategy [37] is said to lack firm plans to improve energy efficiency for most owner occupiers [38] whilst its Energy Security Strategy has been widely criticised for lacking 'a more effective strategy … to drive energy efficiency improvements' [39], contrary to IPCC's report on climate change mitigation [40]. Evidence for health gains and health cost savings, which hardly feature in debates over energy strategy, could strengthen the case for a stable, enduring policy on home energy efficiency measures as called for by the UK Environmental Audit Committee [41].

4.1. Strengths and limitations

The main strengths of this study are its combination of two methodologies, namely a survey of recipients and the examination of secondary data, the latter involving the tracking of hospitalisations over a reasonably long period of time. However, the study is observational rather directly evaluative in that hospitalisations were not linked on an individual basis to the occupants of treated properties, although we took care to focus only on postcodes where the majority of properties received measures. The advent of the Covid-19 pandemic complicates any extrapolation to other time periods.

There are also several respects in which our findings may be context specific. The housing stock in the region, although much of it is post-war, tends to be of relatively low quality and value and, like most regions in Scotland, includes much non-traditional construction with poor thermal properties, offering scope for significant dwelling improvements from upgrading measures [23]. The population, including in particular the treatment group studied here, are older and poorer than the national average, and in relatively worse health in terms of such things as life expectancy and emergency hospital admissions [42]. Indeed, East and North Ayrshire were recently named as two of the top ten districts in the UK for emergency hospital admissions and deaths from lung conditions [43], indicating scope for personal gains from the intervention. On the other hand, Ayrshire has a mild climate with few weather extremes and winter temperatures 5–10° above freezing [44], potentially limiting the gains from energy efficiency improvements compared to elsewhere.

Ethical approval

The Public Health Project Sub-Group of NHS Ayrhsire and Arran confirmed that ethical approval was not required for this analysis as it was part of an ongoing evaluation that had already been agreed, and for which the advice of West of Scotland Research Ethics Service had been sought.

Funding

No funding was provided for this study.

Contributions

Conceptualisation: AK, EC, LM; Methodology: CD, DR; Investigation: MB, CD; Project Administration: AMcG, CD, BM; Resources: AMcG; Analysis: MB, DR; Data Curation: MB, DR; Writing – Draft Preparation: AK; Writing – Review and Editing: MB, AMcG, DR.

Data

The data used in this study are in the ownership of NHS Ayrshire and Arran and are not openly available. Further information about the data and conditions for access are available from "Rae, David.Rae2@aapct.scot.nhs.uk.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Three of the authors – Bhagat, McGonigle and Marquis – work for the Energy Agency which is responsible for delivering the energy efficiency programme studied here.There are no other competing interests.

Acknowledgements

We would like to acknowledge the work of Energy Agency staff who delivered the programme of energy efficiency works and all the housing occupants who participated in the survey.

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